BREEDING BEHAVIOUR AND MORPHOMETRIC RELATION OF *BUFO STOMATICUS* LUTKEN (ANURA : AMPHIBIA)[1]

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(With a text-figure)

Breeding behaviour and morphometric measurements of *Bufo stomaticus* Lutken toads kept in a froggery were studied. Moderate temperature and high humidity during monsoon are favourable environmental conditions for egg laying. Male-male competition for mounting a female was common but in no case could the competing male separate the amplexed male. Amplex duration was 1-4 days. The clutch size varied from 9,000 to 11,000 eggs arranged in two parallel rows of jelly strings. The female toads were always larger than the males. Male and female toads found in amplexus were bigger than their non-amplexed population. Significant positive correlations between snout-vent length with body weight and with femur length were observed in the toads irrespective of sex and age. Such a correlation was also observed between body weight and gonad weight of immature and adult toads (toads more than five month old).

INTRODUCTION

The reproductive capacity of adults and the successful metamorphosis of the tadpoles lead to the abundance of adult anurans. Environmental factors such as rainfall, humidity, light and temperature have a profound effect on breeding activity (Savage 1961). Previous studies (Mohanty-Hejmadi 1974, Daniel 1975, Dutta and Mohanty-Hejmadi 1976, Mohanty-Hejmadi and Dutta 1979, Dash and Hota 1980, Mishra and Dash 1984) reported the breeding habits of some Indian amphibians. Mohanty and Das (1978) and Mohanty (1984) have reported on the induced breeding in Indian frogs. Khan (1965) prepared a life table for *Bufo stomaticus*. *B. stomaticus* is a common toad of this region and considering the scant literature on its breeding behaviour and morphometry, we studied these aspects.

EXPERIMENTAL DESIGN

During the 1983 monsoon adult *Bufo stomaticus* toads were collected from beneath lamp posts in residential areas of Sambalpur University Campus, Sambalpur, Orissa and kept in the University's froggery. Some of them were selected sex-wise and morphometric measurements like total body length (snout to vent), femur length and body weight were recorded (N = 41 male and N = 45 female). These animals were killed and dissected to note the nature and weight of the gonads. The behaviour of mature toads during amplexus and egg laying were studied in the froggery. Morphometric measurements of amplexing pairs were also taken to determine the size at maturity.

Juvenile toads, metamorphosed in the laboratory, were maintained in the froggery only for five months as provisioning of food to the growing immatures was a big problem. The body length, femur length, body weight and gonad weight of these juveniles and immatures were measured sex-wise to determine growth rate (N = 20 male and N = 24 female). Climatological data for the area were collected from the Hirakud Research Station.

RESULTS

Climate: The study area experiences mainly three seasons (i) summer from March to mid June, (ii) rains from mid June to mid October and (iii) autumn-winter from mid October to February. The maximum and minimum air temperatures recorded were 39.7°C in summer and 13.2°C in winter during 1983. RH was 91.6% at 08.30 hrs and 54.6% at 1730 hrs IST during the rainy season in 1983. The total rainfall in 1983 was 1497.1 mm with 112 rainy days. About 90% of total rain fell in the rainy season.

Habits and habitat: *Bufo stomaticus* Lutken, commonly known as the marbled toad, is found in India, Pakistan, Nepal and Sri Lanka. They are nocturnal and hide under stones and soil during the day. In summer they aestivate under earth even at a depth of over a metre (Rao 1923). The toads are equally at home under varying climatic conditions and during the breeding season, could be seen moving around

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TABLE 1
STATISTICAL RELATIONSHIP BETWEEN DIFFERENT MORPHOMETRIC PARAMETERS IN *Bufo stomaticus*

Morphometric parameters	Collected from	Sex	Regression equation	'r'	df	Significance
Body weight (Y) with S-V length (X)	Field	Male	Y = 0.952 x – 30.52	0.942	39	P <0.001
Femur length (Y) with S-V length (X)	-do-	-do-	Y = 0.388 x + 0.324	0.971	39	P <0.001
Testis weight (Y) with body weight (X)	-do-	-do-	Y = 2.111 x – 4.34	0.894	32	P <0.001
Body weight (Y) with S-V length (X)	-do-	Female	Y = 1.493 x– 63.718	0.896	43	P <0.001
Femur length (Y) with S-V length (X)	-do-	-do-	Y = 0.34 x + 2.077	0.917	43	P <0.001
Ovary weight (Y) with body weight (X)	-do-	-do-	Y = 0.221 x– 3.397	0.838	28	P <0.001
Body weight (Y) with S-V length (X)	Laboratory reared juveniles	Male	Y = 0.186 x– 2.694	0.956	18	P <0.001
Femur length (Y) with S-V length (X)	-do-	-do-	Y = 0.4164 x–1.104	0.985	18	P<0.001
Testis weight (Y) with body weight (X)	-do-	-do-	Y = 0.585 x + 2.039	0.518	11	ns at P0.05
Body weight (Y) with S-V length (X)	-do-	Female	Y = 0.253 x– 4.516	0.677	22	P <0.001
Femur length (Y) with S-V length (X)	-do-	-do-	Y = 0.4372 x–1.942	0.918	22	P<0.001
Ovary weight (Y) with body weight (X)	-do-	-do-	Y = 2.638 x + 17.887	0.34	18	ns at P<0.05

S-V = Snout-Vent ns = not significant

TABLE 2
LENGTH AND WEIGHT OF MALE AND FEMALE *B. stomaticus* TAKEN FROM DIFFERENT CONDITIONS

Conditions	Morphometric parameter		Sex male	Sex female	Value of 't'
Field collection	S-V length (mm)	N	41	45	t = 12.69
		$\bar{X}$	58.83	67.42	df = 84
		SD	10.421	9.307	P <0.001
	Body weight (g)	N	41	45	t = 14.63
		$\bar{X}$	25.49	36.94	df = 84
		SD	10.528	15.514	P <0.001
Laboratory reared	S-V length (mm)	N	20	24	t = 6.16
		$\bar{X}$	25.25	29.42	df = 42
		SD	7.297	3.111	P <0.001
	Body weight (g)	N	20	24	t = 2.542
		$\bar{X}$	2.003	2.927	df = 42
		SD	1.419	1.46	P <0.002
Amplexus	S-V length (mm)	N	10	10	t = 10.65
		$\bar{X}$	64.1	73.8	df = 18
		SD	3.9	4.392	P <0.001
	Body weight (g)	N	10	10	t =18.37
		$\bar{X}$	34.3	54.13	df = 18
		SD	3.959	7.69	P <0.001

SD = Standard deviation S-V = Snout-Vent

during the day. They are solitary in nature but in captivity rested together in a jumbled heap. In captivity they fed on termites and earthworms. Adults are medium sized, measuring up to 81 mm, with heavily tuberculated skin.

Sexual dimorphism: Mature toads exhibit distinct sexual dimorphism. Males are smaller than females (average snout-vent length 64.1 mm and 73.8 mm, average body weight 34.3 g and 54.13 g in case of amplexing males and females respectively) and develop secondary sexual characters like a black vocal sac and black cornified patches on the inner sides of the first and second fingers. During the breeding season sexually mature males could be distinguished from others by the characteristic bright yellow body colour.

Amplexus: The pairing pattern was observed among the toads kept in the froggery. During the breeding season males produced a characteristic sound to attract female conspecifics. At first the male jumped onto the back of the female and clung to it by holding it below the arm pits with its forearms, and formed an amplexing pair which lasted for 1 to 4 days. During this period the female carried the male on its back while moving from place to place.

Neither male nor female toads exhibited any mate choice. Male-male pairing was avoided by producing a peculiar croaking if a male by chance climbed over another male. Male-male competition for a single female was prevalent.

In such cases a mature male first approached an amplexed pair, then rode over the pairing male and tried to separate the pair. During the course of the present investigation it was observed that in no case was the competing male successful in separating the amplexed male. It was also observed that considerable amount of force was required to separate the male from the amplex pairing so as to take morphometric measurements of the amplexed individuals.

Eggs and egg laying: Before egg laying the amplexed pairs moved towards a water source. Just before egg laying the female settled down near the water source. The male brought its hind limbs together to form a pouch into which the female released a number of eggs at a time. The male then ejaculated spermatic fluid over the eggs. After egg laying the female regained its normal position and the male withdrew its hind legs, allowing the egg strings to become loose. In this way eggs were laid in many instalments, hence the complete egg laying process lasted for 1 to 2 hours. Due to their sticky nature and the changing of position by the female after each instalment of egg laying, the egg strings were spread out.

The eggs were laid in two parallel rows of jelly strings entangled with the submerged substratum. Clutch size varied from 9,000 to 11,000 (by volume count). The average diameter of an egg was 1.3 mm. In laboratory condition eggs took 24 hours to hatch and the percentage of hatching depended on the spreading pattern of the egg strings. This toad generally breeds from mid June to September but the maximum number of breeding pairs was observed in July. In nature the toads even laid eggs in small garden pits having water level of 2 cm depth and drying of such pits might be one of the main causes for natural mortality of the larvae.

Morphometric relationship: Morphometric measurements such as snout-vent (S-V) length, femur length, body weight and gonad weight of the toads were taken sex-wise and the relationships between different parameters were analysed statistically. Results of the analysis (Table 1) indicated that there was significant positive correlation between body weight and S-V length, femur length and S-V length of male and female toads. The positive correlation between body weight and gonad weight was significant in the case of field population but statistically insignificant for juvenile toads reared in the froggery. Toads forming amplexus were larger and fatter than the non-amplexing toads (Table 3).

Discussion

Factors which affect oviposition have an important bearing on breeding biology. Packer (1960) found that breeding migration of *Terich rivularis* was provoked by rainfall. Alcala (1962) pointed out the necessity of rain for breeding to occur in *Rhacophorus leucomystax*. Dimmitt and Ruibal (1980) have listed sound/vibration as the primary and temperature, time of the day, amount of rainfall on preceding day, change in soil moisture etc. as secondary factors that may affect emergence of *Scophiopus couchi* from their winter burrows. During the present investigation oviposition was initiated by onset of monsoon rains and increased RH. Rain is necessary for breeding; this is supported by

the fact that more clutches were collected in July, the month of heavy rains. With the initiation of rains air temperature decreased from an average of 39.7° C in May to 33.2° C in July. During the monsoon moderate air temperature is coupled with high RH, particularly in the morning hours. We have observed that almost all the amplex pairs (N = 50) laid eggs during the morning hours (0700 to 1000 hrs) when low temperature and RH prevailed.

The mean size of the males in amplexus is greater than the mean size of the total male population (Gittins *et al.* 1980). Howard (1981) and Hemelaar (1983) concluded that at any stage adult female toads are bigger than adult male toads. Howard's (1981) view is that this difference in weight between female and male bull frogs is not the result of differential growth rate, but rather a sex-specific difference in the life history. This is also true in the case of *B. stomaticus*, where the females are larger than the males (Table 2) even from the very early juvenile stage (Fig. 1). We also observed that individuals found in amplexus are larger than the non-amplexing individuals (Table 3). These findings strengthen the view that female anurans are typically larger than their male counterparts (Crump 1974, Shine 1979).

Female reproductive success is determined more by the number of eggs laid than the number of

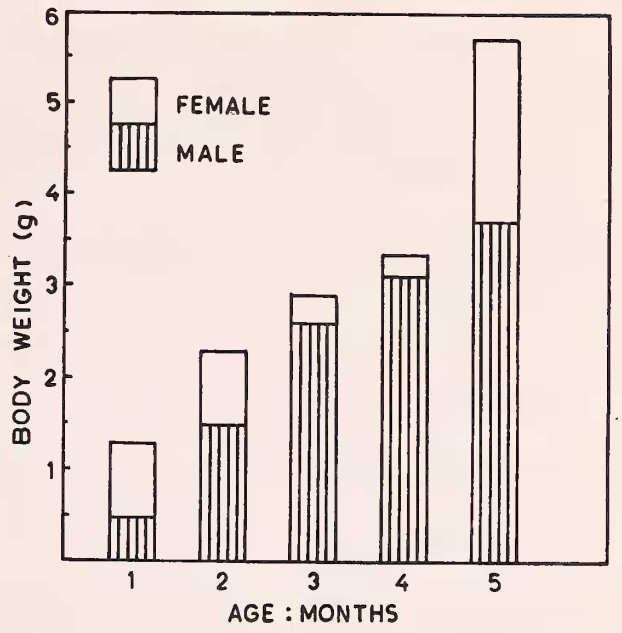

Fig. 1. Body mass histograms showing differential growth of male and female *B. stomaticus* with age.

young reared, and large female size permits a capacity for greater volume of eggs in each clutch (Howard 1981). In the present study the mean body mass of female *B. stomaticus* in amplexus was greater than that of the non-amplexing female population and the clutch size was found to be 9000 to 11000, a value much more than in other anurans like ranids, rhacophorids and hylids (Table 4). Such an observation extends support to the view that larger female body size may confer a reproductive

TABLE 3
A COMPARISON OF LENGTH AND WEIGHT OF MALE AND FEMALE *B. stomaticus* TOADS FOUND IN AMPLEXUS vs. FIELD POPULATION

Sex	Morphometric parameter		Condition of toads		Value of 't'
			Amplexing individuals	Field population	
Male	S-V length (mm)	N	10	41	t = 4.92
		$\bar{X}$	64.1	58.83	df = 49
		SD	3.9	10.421	P < 0.001
	Body weight (g)	N	10	41	t = 8.182
		$\bar{X}$	34.3	25.49	df = 49
		SD	3.959	10.528	P < 0.001
Female	S-V length (mm)	N	10	45	t = 6.27
		$\bar{X}$	73.8	67.42	df = 53
		SD	4.392	9.307	P < 0.001
	Body weight (g)	N	10	45	t = 13.2
		$\bar{X}$	54.13	36.94	df = 53
		SD	7.69	15.514	P < 0.001

SD = Standard Deviation S.V. = Snout-Vent

TABLE 4
A COMPARISON OF THE CLUTCH SIZE IN DIFFERENT ANURAN SPECIES

Species	Clutch size	References
Rana tigerina	1200–1800	Dash and Hota (1980), Pandian and Marian (1986)
Rana cyanophlyctis	980 –1538	Pandian and Marian (1986)
Polypedates maculatus	622	Mishra and Dash (1984)
Hyla sp.	221–482	Pandian and Marian (1986)
Bufo melanostictus	2000 –5000	Hota (1984), Pandian and Marian (1986)
Bufo stomaticus	9000–11000	Present study

advantage in many anurans due to a positive relationship between clutch size/volume and body size (Salthe and Duellman 1973, Crump 1974). Eggs were laid in two parallel strings, which confirms the description of Khan (1982) for identification of the eggs of *B. stomaticus*.

During hibernation the ovaries and oviducts practically do not change in weight (Zuszczyk and Zamachowski 1973). Young females below a particular size threshold do not mature sexually (Howard 1981). We have observed that gonad weight is significantly positively correlated with body weight in the case of bigger sized toads collected from the field, but insignificant in five month old juveniles reared in the froggery. The relationship is perhaps age specific.

REFERENCES

ALCALA, A.C. (1962): Breeding behaviour and early development of frogs of Negros, Philippine Island. *Copeia 1962*: 679-726.

CRUMP, M.L. (1974): Reproductive strategies in a tropical community. Miscellaneous Publications 61. University of Kansas Museum of Natural History, Lawrence, Kansas, U.S.A.

DANIEL, J.C. (1975): Field guide to the amphibians of Western India, part 3. *J. Bombay nat. Hist. Soc. 72(2):* 506-522.

DASH, M.C. & HOTA, A.K. (1980): Density effects on the survival, growth rate and metamorphosis of *Rana tigrina*. tadpoles. *Ecology 61(5):* 1025-1028.

DIMMITT, M.A. & RUIBAL, R. (1980): Exploitation of food resources by spadefoot toad (*Scophiopus*). *Copeia 1980(4):* 854-862.

DUTTA, S.K. & MOHANTY-HEJMADI, P. (1976): Breeding and life history of the Indian bull frog, *Rana tigrina*. *Prakruti, Utkal Univ. J. Sci. 13 (1 & 2):* 53-59.

GITTINS, S.P., PARKER, A.G. & SLATER, F.M. (1980): Mate assortment in the common toad (*Bufo bufo*). *J. Nat. Hist. 14:* 663-668.

HEMELAAR, A.S.M. (1983): Age of *Bufo bufo* in amplexus over the spawning period. *Oikos 40:* 1-5.

HOTA, A.K. (1984): Growth, production and energetics of tadpoles of *Rana tigrina* (Daud.) and *Bufo melanostictus* (Blouch and Schneider). Ph.D. Thesis. Sambalpur University, Orissa.

HOWARD, R.D. (1981): Sexual dimorphism in bull frogs. *Ecology 62 (2):* 303-310.

KHAN, M.S. (1965): A normal table of *Bufo stomaticus* Lutken. *Biologia 11:* 1-39

KHAN, M.S. (1982): Collection, preservation and identification of amphibian eggs from the plains of Pakistan. *Pakistan J. Zool. 14(2):* 241-243.

MISHRA, P.K. & DASH, M.C. (1984): Metamorphosis of *Polypedates maculatus* (Gray 1830): An analysis of crowding effect. *Alytes 3(4): 163-172.*

MOHANTY, S.N. (1984): Autecology of *Rana tigrina* (Daud.). Ph.D. Thesis. Sambalpur University, Orissa.

MOHANTY, S.N. & DAS, C.R. (1978): Effects of hypophysation on a partially ovulated Indian bull frog, *R. tigrina*. *In:* Symposium on Comparative Endocrinology held at Utkal University, Orissa.

MOHANTY-HEJMADI, P. (1974): Amphibian fauna of Orissa. *Prakruti, Utkal Univ. J. Sci. 11 (1 & 2)*: 89-97.

MOHANTY-HEJMADI, P. & DUTTA, S.K. (1979): Breeding and development of *Rana cyanophlyctis* Schneider. *J. Bombay nat. Hist. Soc. 76(2):* 291-296.

PACKER, W.C. (1960): Bioclimatic influences on the breeding migration of *Taricha rivularis*. *Ecology 4:* 509-517.

PANDIAN, T.J. & MARIAN, M.P. (1986): Production and export of frogs: an ecological view. *In:* Proceedings of First World Conference on Trade in Frog legs vis-a-vis Environmental Considerations, Calcutta, India: 33-48.

RAO, C.R.N. (1923): Quoted from 'Field guide to the amphibians

of Western India' by J.C. Daniel. *J. Bombay nat. Hist. Soc. 60(2):* 415-438.

SALTHE, S.N. & DUELLMAN, W.E. (1973): Quantitative constraints associated with reproductive mode in anurans. *In:* J.L. Vial, ed. Evolutionary biology of the anurans. Univ. of Missouri Press, Columbia: 229-249.

SAVAGE, R.M. (1961): The ecology and life history of the common frog (*Rana temporaria temporaria*). Sir Issac Pitman and Sons Ltd., London: 221.

SHINE, R. (1979): Sexual selection and sexual dimorphisms in the amphibia. *Copeia 1979:* 297-306.

ZUSZCZYK, W. & ZAMACHOWSKI, W. (1973): Morphological changes in the reproductive organs of the female edible frog, *Rana esculenta* (L.) in the annual cycle. *Acta Biol. Cracov. Ser. Zool. 16:* 167-178.